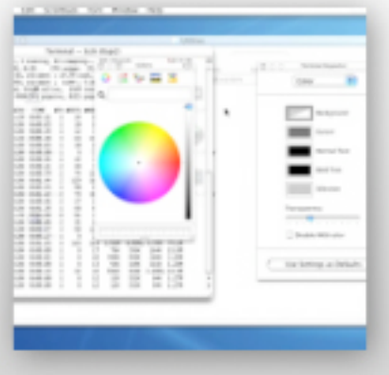
Kerberos in Mac OS X

Session 108



Kerberos in Mac OS X

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Kerberos Overview

- What is Kerberos?
- How Kerberos works
- Kerberos infrastructures
- New features of Kerberos in Panther
- How to add Kerberos to your application
- Summary and wrap up
- Questions and answers

What Is Kerberos?

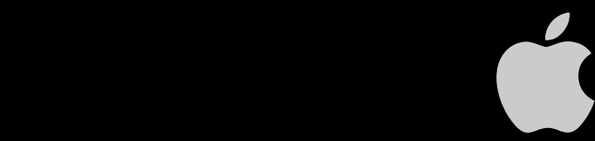
- A secure network authentication system
  - Authentication versus Authorization
- Proves who you are
- Uses a trusted third-party security model

Who Uses Kerberos?

- Government
- Large corporations
- Higher education
- Every Windows 2000 (or later) installation
- Mac OS X 10.1 and later

Why Do They Use It?

- Factors security problem
  (Authentication vs. Authorization)
- Consistent with centralized authentication goals
- Single sign-on
- Ubiquitous
  - Windows, Solaris, Mac OS X, Linux, AIX, Xbox Live…
- Time tested
- Source freely available



Kerberos for Macintosh

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Brief Kerberos History

- Developed in the 1980s as part of MIT's Project Athena
- IETF proposed standard in 1993
- Selected as the default authentication method in Windows 2000 and later
- Selected by Apple as the default authentication method in Mac OS X Panther and later
- Large increase of use in the enterprise market

Kerberos Protocols

- Kerberos v4
  - Original version, no longer developed
  - Still in use at many long-standing Kerberos sites
- Kerberos v5
  - Current version of the Kerberos protocol
  - Designed to solve many deficiencies and security problems in Kerberos v4

Kerberos Terms

- Realm
  - The administrative unit protected by a Key Distribution Center (KDC)
- Ticket
  - An authentication token
  - Different types of tickets for different purposes
  - Have a finite lifetime; they expire
  - Also known as “credentials”

Kerberos Terms

- Ticket-granting ticket (TGT)
  - An initial ticket that grants permission to get service tickets
- Service ticket
  - A ticket that authenticates the user to a particular service (for instance, e-mail, ftp, login)

Realm

- Looks similar to an Internet domain
  - ATHENA.MIT.EDU
- Defines your namespace
- Unlike DNS, a Kerberos realm is case sensitive
- Can have trust relationships between realms
- Can support any combination of v4 and v5
- As few realms as possible in an organization is best

Ticket-Granting Ticket (TGT)

- Also called “initial ticket” because it is the first ticket a client gets
- Proves that the client is allowed to get tickets for other services
- Acts as a substitute for password
- Mechanism by which single sign on is achieved
- Only valid for a limited period of time (expires), although can be renewable

Getting a TGT

Client asks KDC for TGT

Getting a TGT

KDC returns a TGT and session key to a client encrypted with client's key

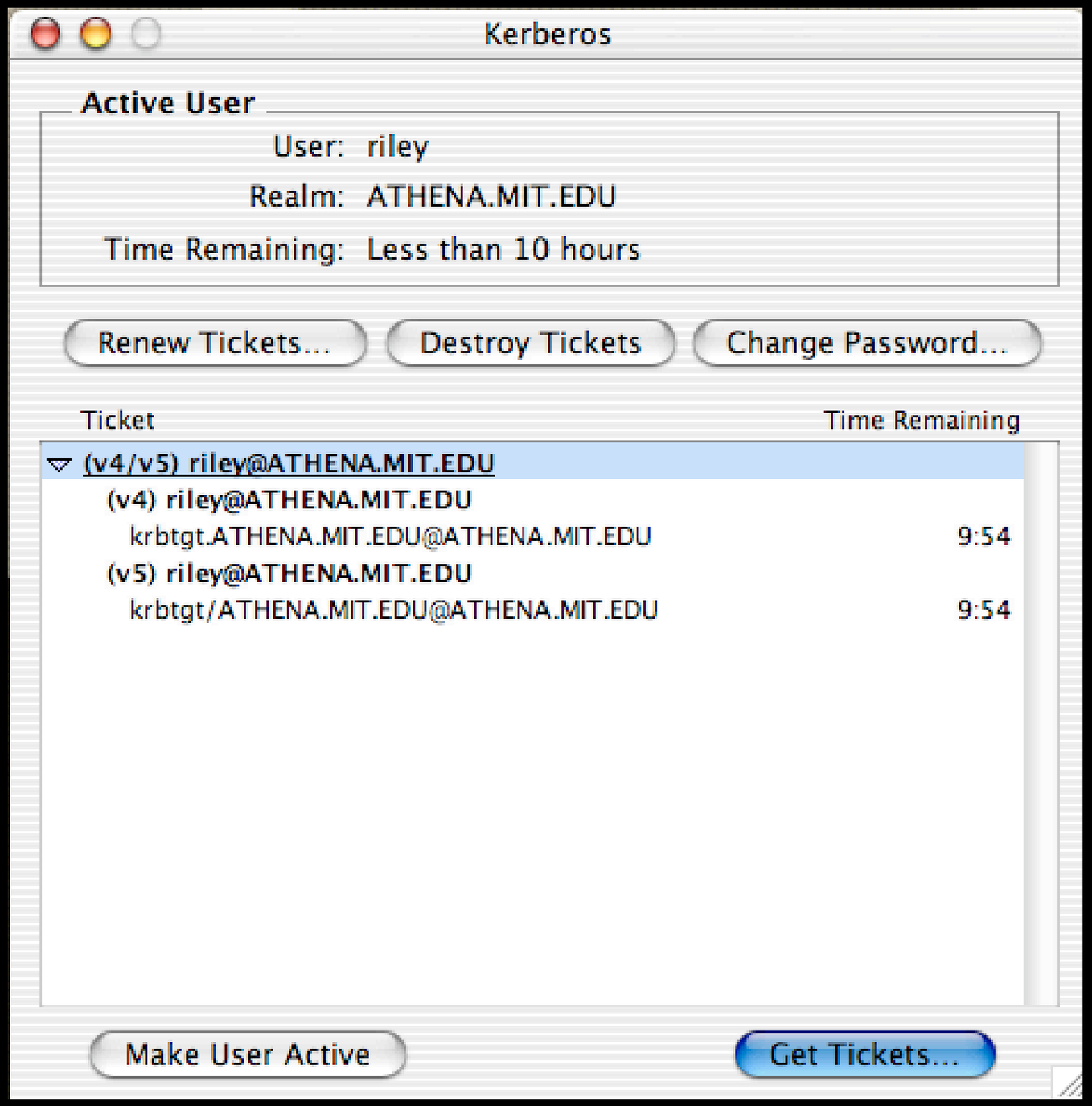
Getting a TGT

Client uses client's key (one-way hash of password) to extract TGT

KDC

Client
TGT

Getting a TGT

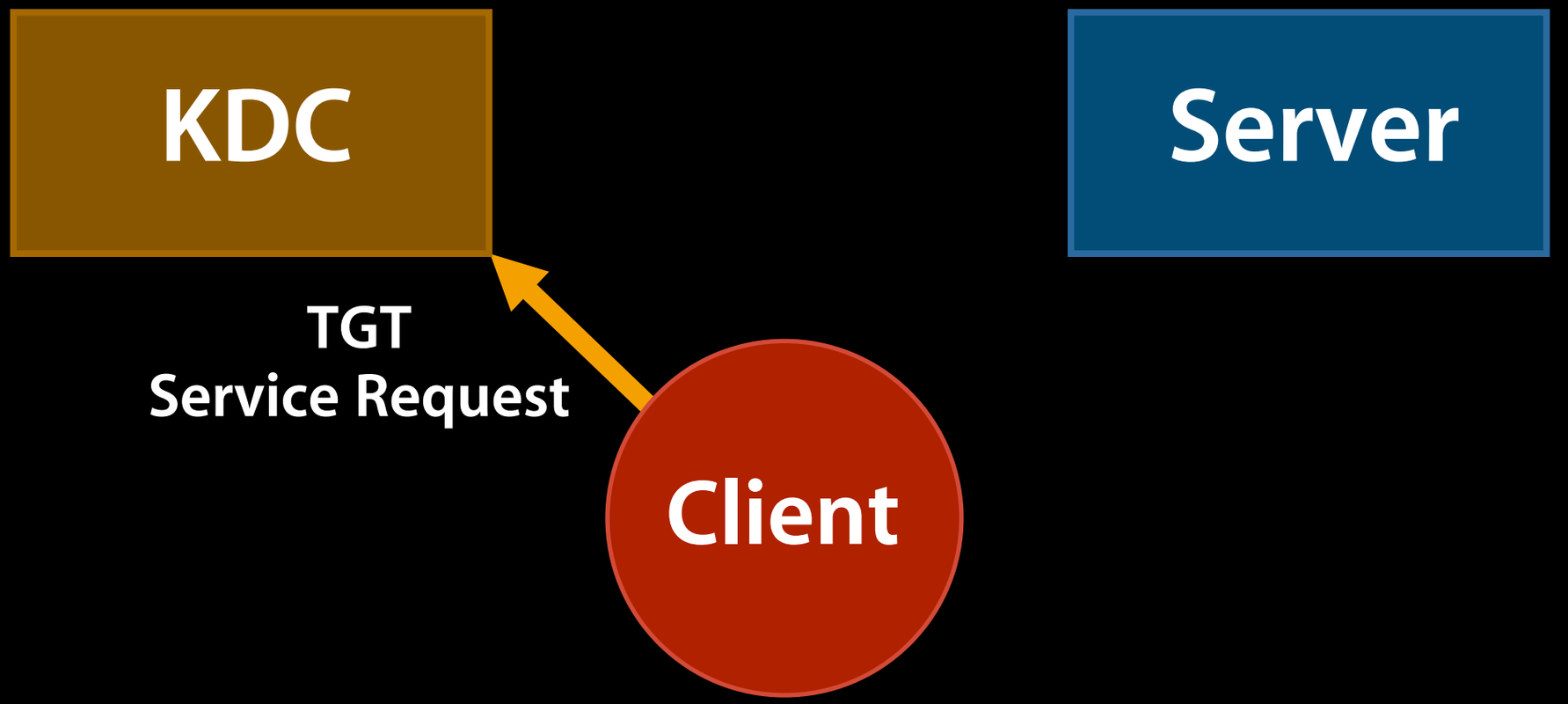


Service Ticket

- Ticket used by client to get access to particular service or server (for instance, ftp, mail, ssh)
- Contains a session key that is shared between the client and server that they can use to encrypt data exchanges
- Also expires

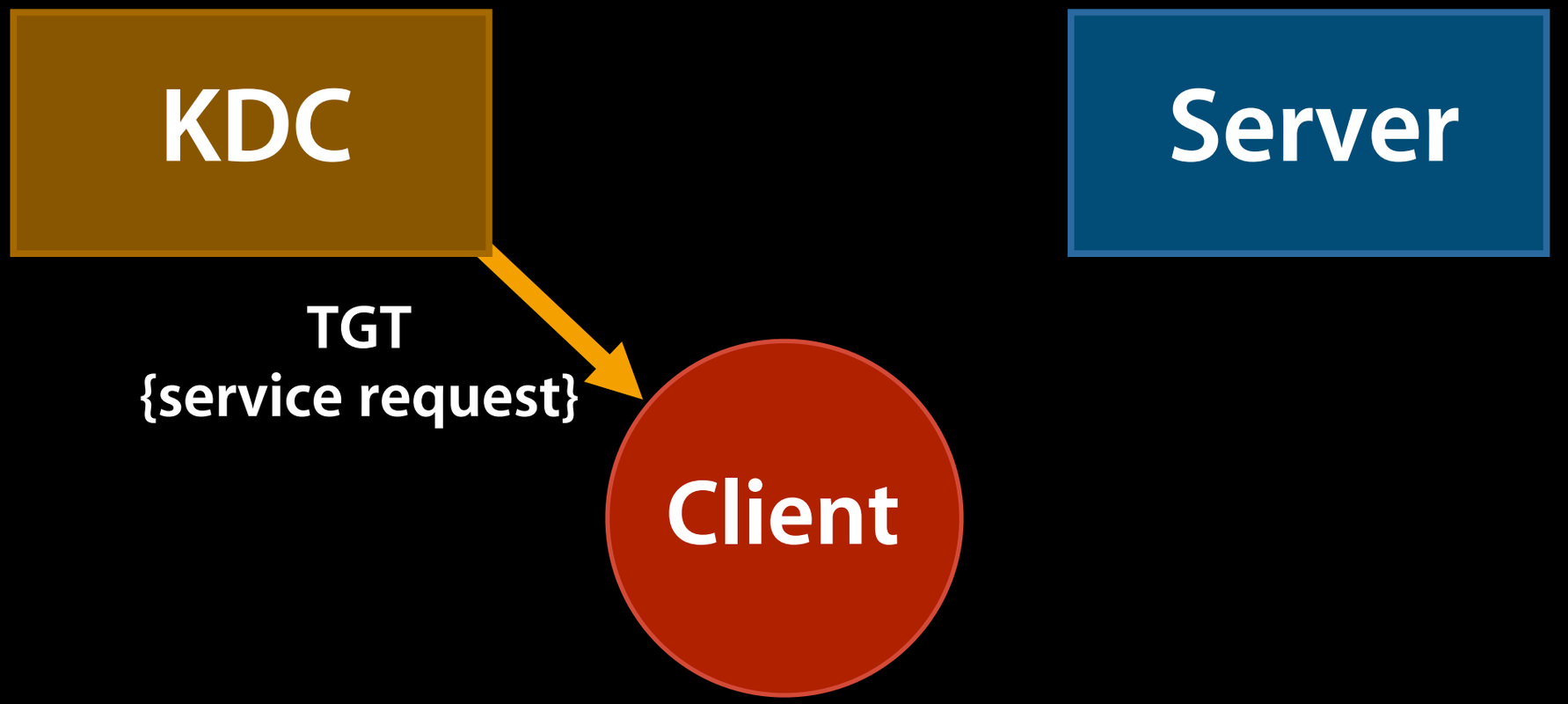
Getting a Service Ticket

- Client presents TGT to KDC with a request for a service ticket



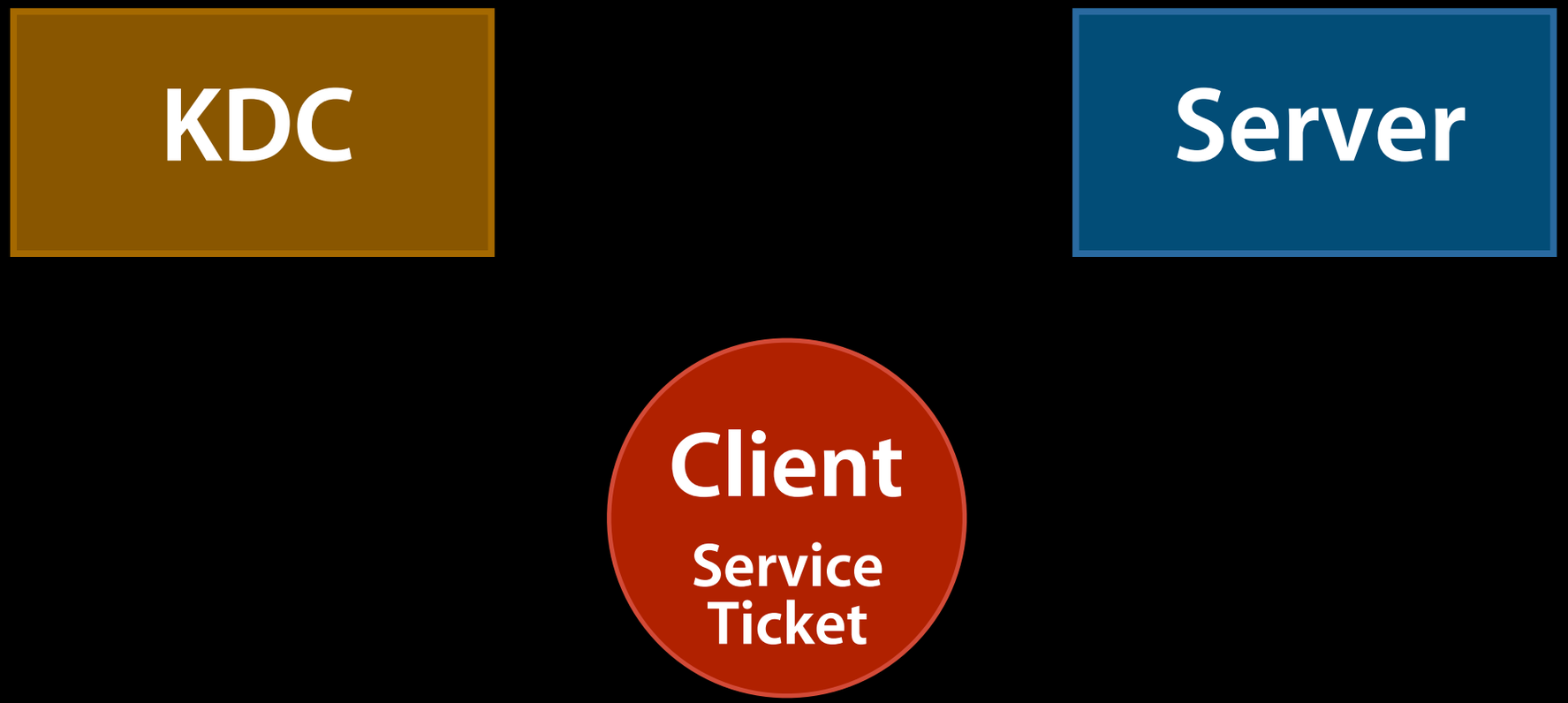
Getting a Service Ticket

- KDC returns encrypted service ticket to client



Getting a Service Ticket

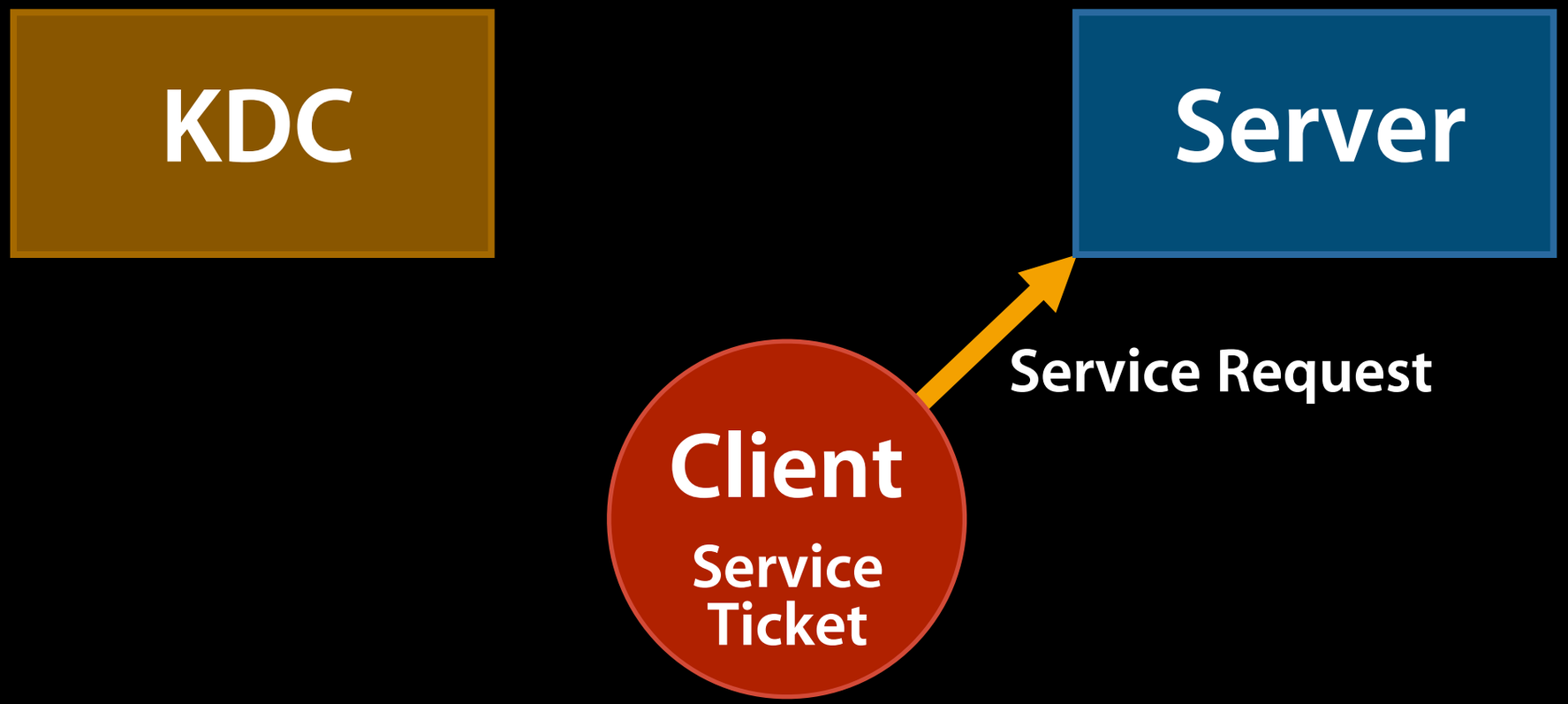
- Client uses TGT to extract service ticket



Connecting to a Service

One-way authentication

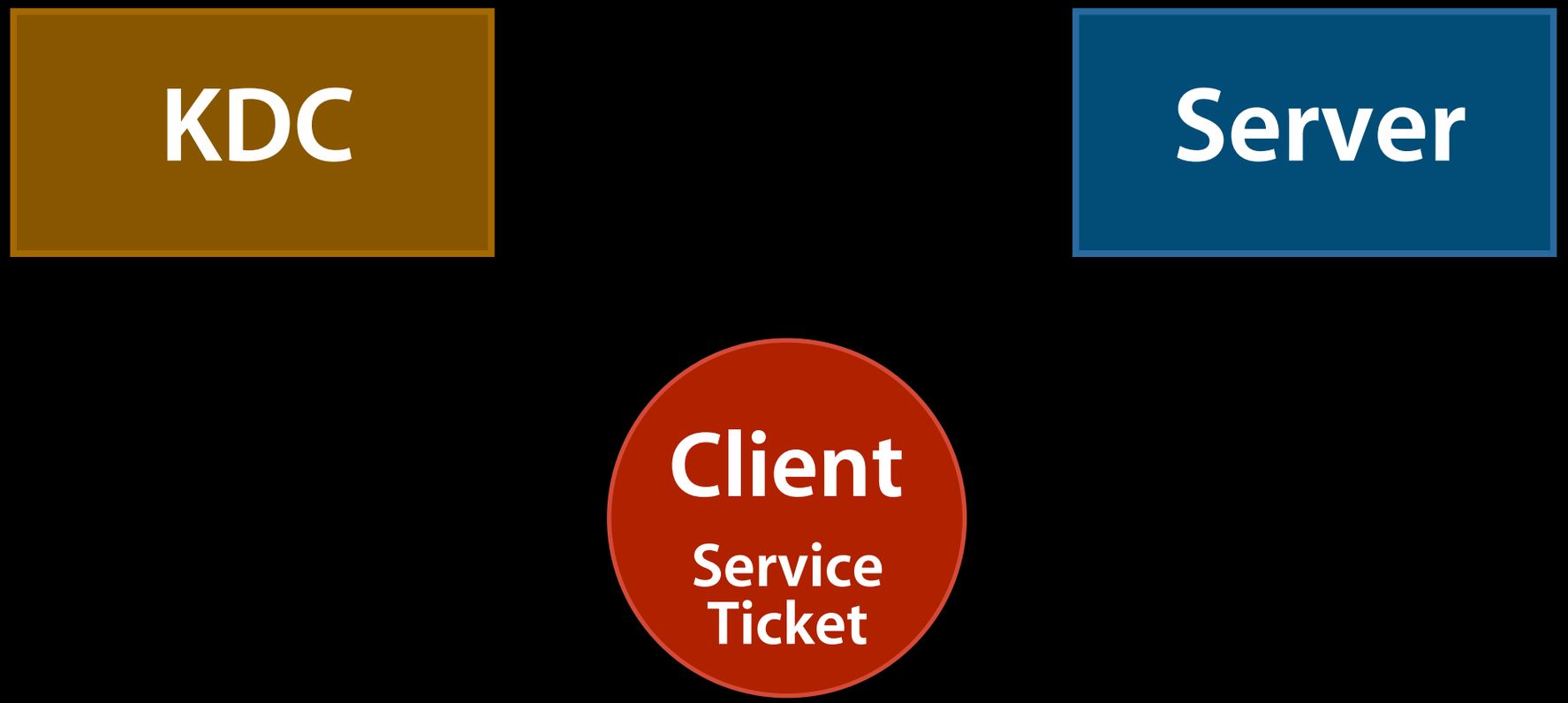
- Client presents service ticket to server



Connecting to a Service

One-way authentication

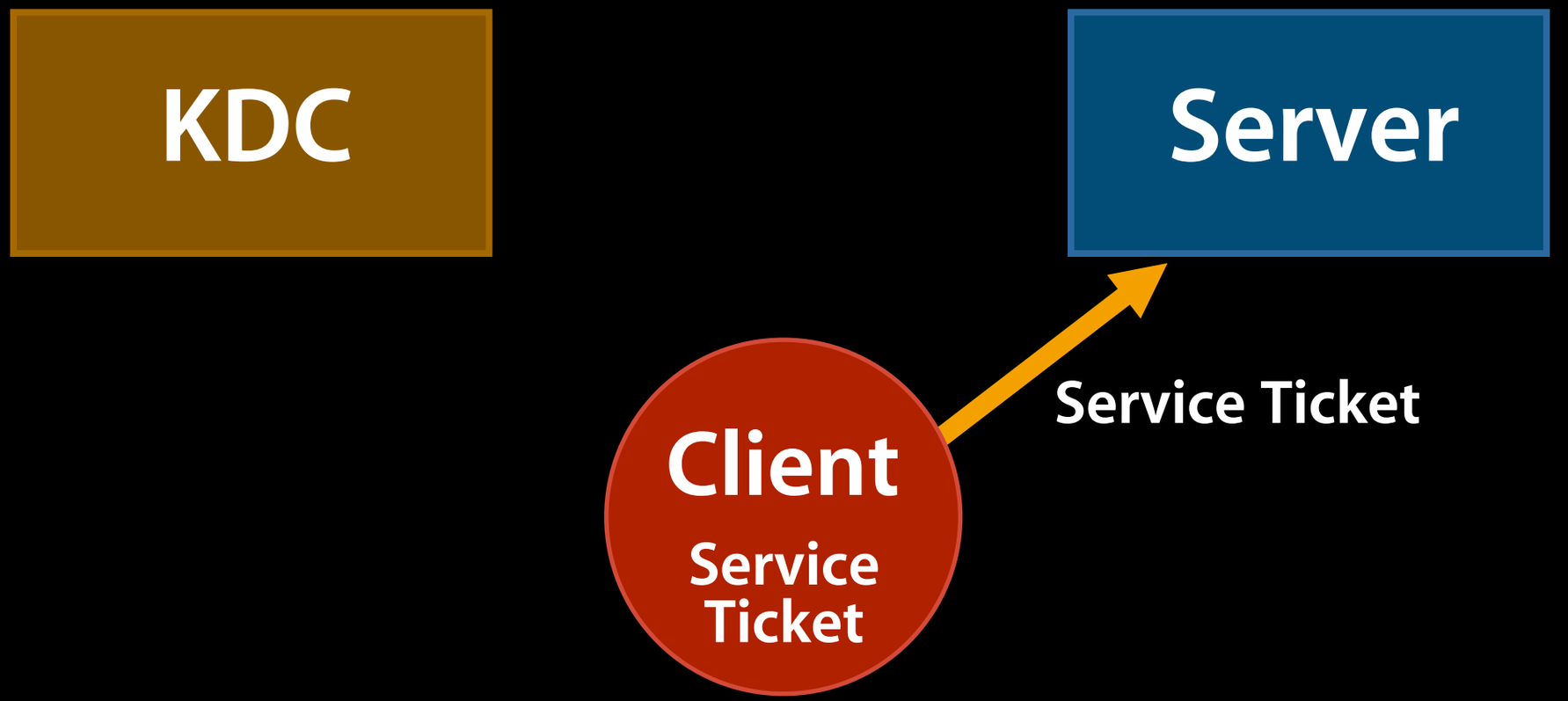
- Server receives service ticket and authenticates the client
- Server should use session key from service ticket to encrypt subsequent traffic between client and server



Connecting to a Service

Mutual authentication

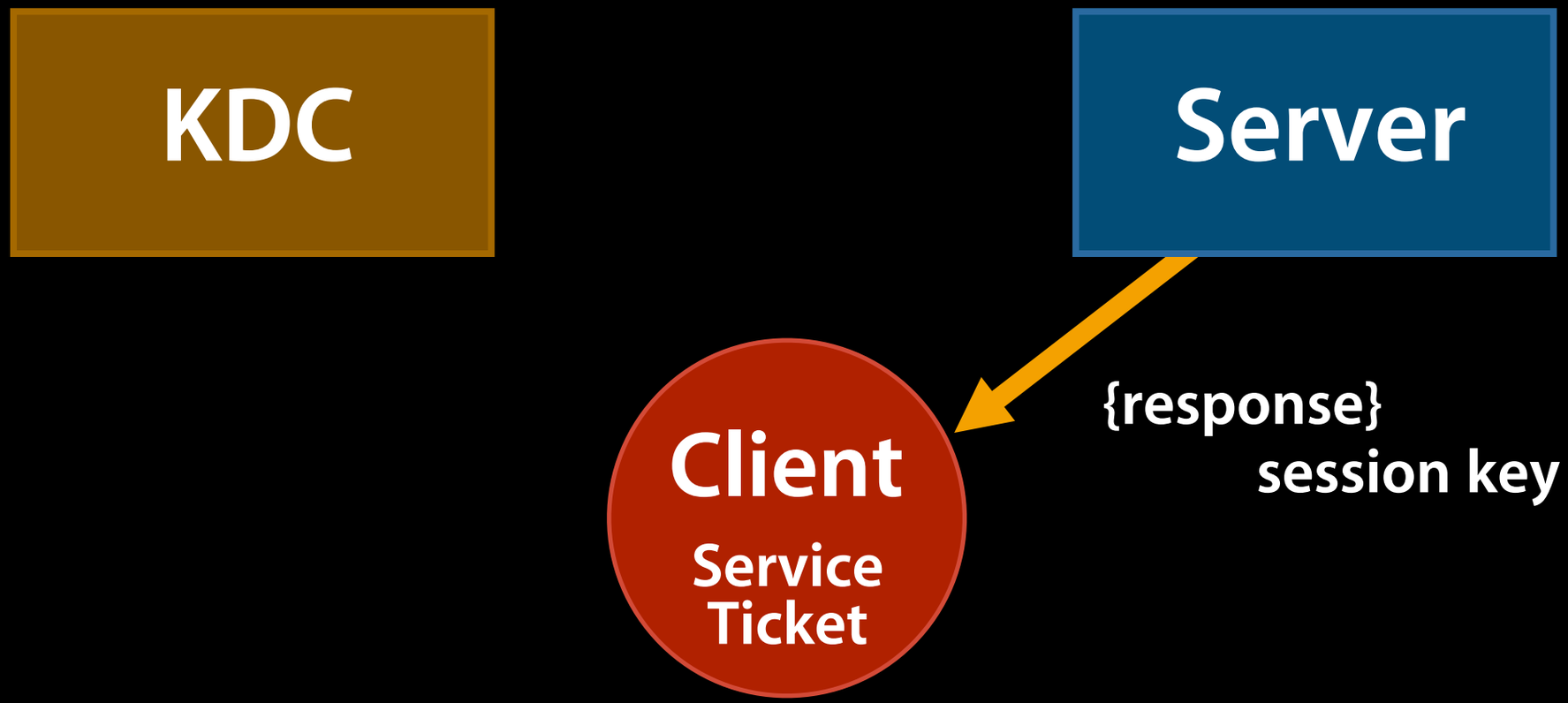
- Client sends service ticket containing session key to server



Connecting to a Service

Mutual authentication

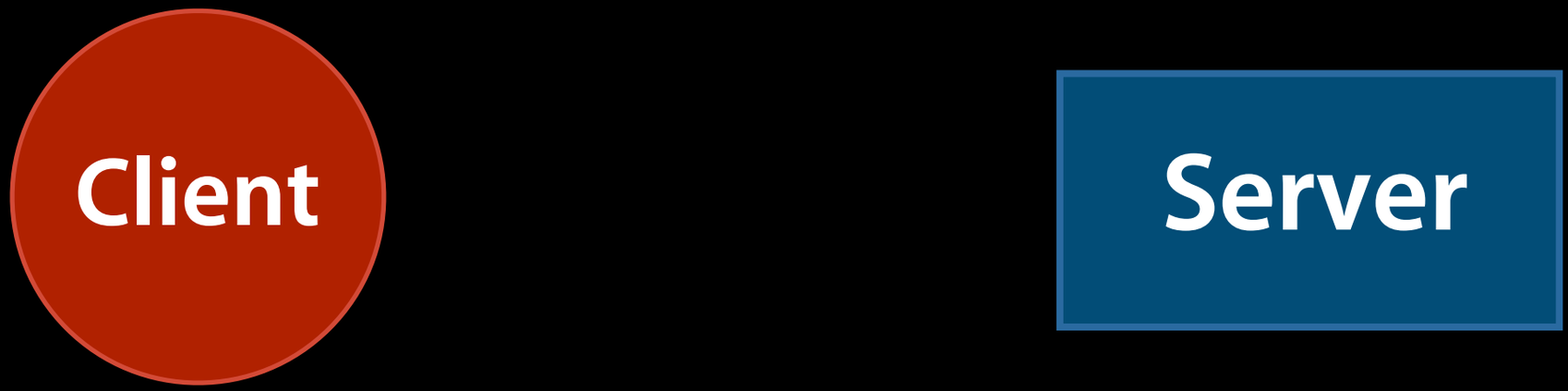
- Server returns a response encrypted with session key from service ticket, authenticating server to client
- Server should also use session key to encrypt subsequent traffic between client and server



Connecting to a Service

IMAP example

- Uses Simple Authentication and Security Layer (SASL) for security
- Use of SASL implies GSSAPI for Kerberos v5
- Base 64 encoded protocol data



Connecting to a Service

IMAP example

- Client requests server capabilities

Connecting to a Service

IMAP example

- Server lists capabilities including GSSAPI

Connecting to a Service

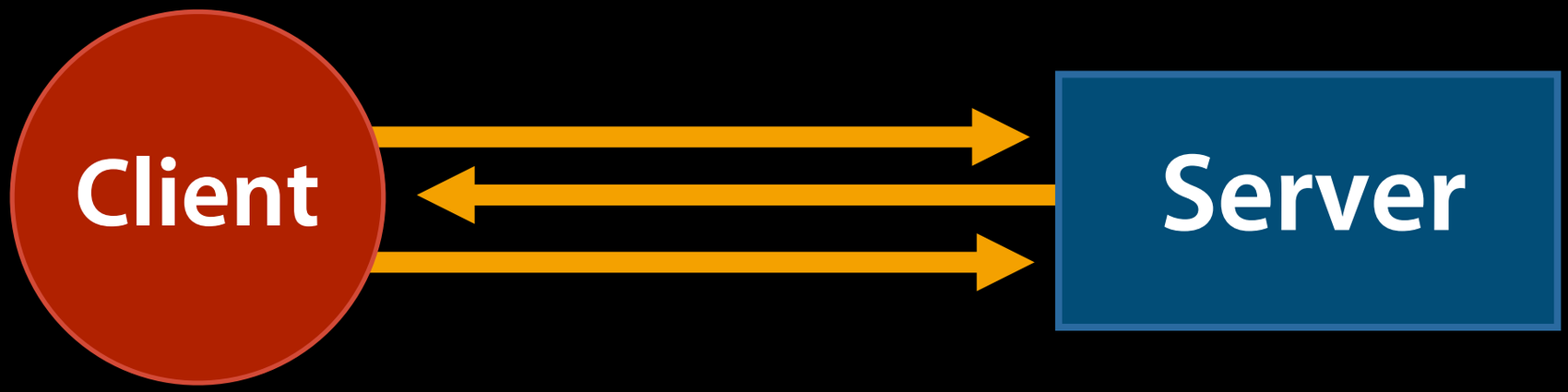
IMAP example

- Client selects GSSAPI

Connecting to a Service

IMAP example

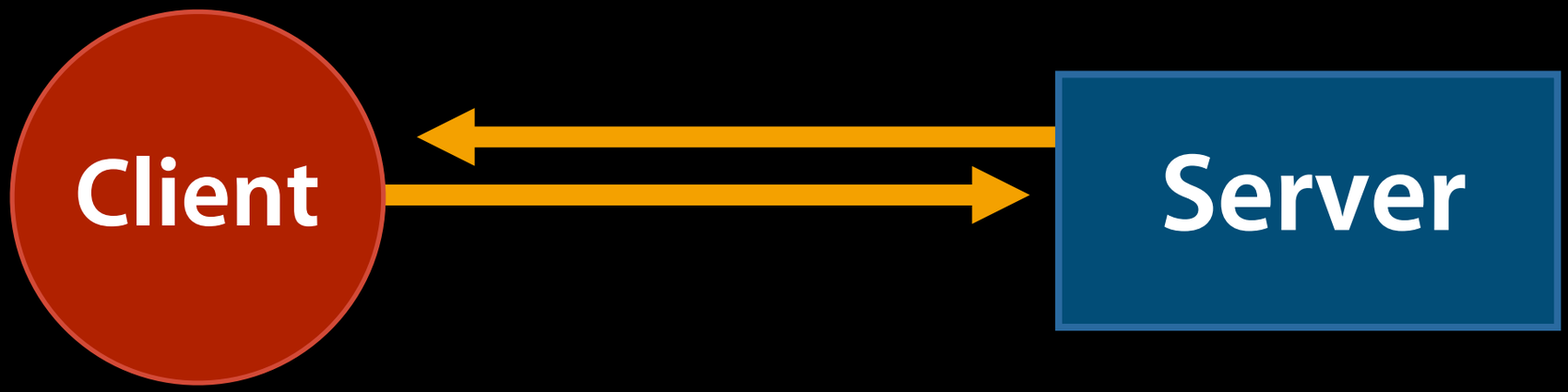
- Client selects GSSAPI
- Kerberos authenticator sent as part of a GSSAPI token



Connecting to a Service

IMAP example

- Server sends mutual authentication response as part of a GSSAPI token
- Client responds with an acknowledgment



Connecting to a Service
IMAP example

- Server sends back security options (buffer size, whether encryption should be used)

Connecting to a Service

IMAP example

- Clients sends who it wants to log in as and selects encryption

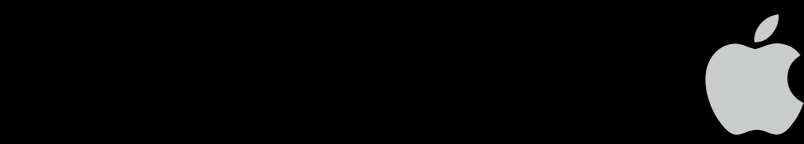
Connecting to a Service

IMAP example

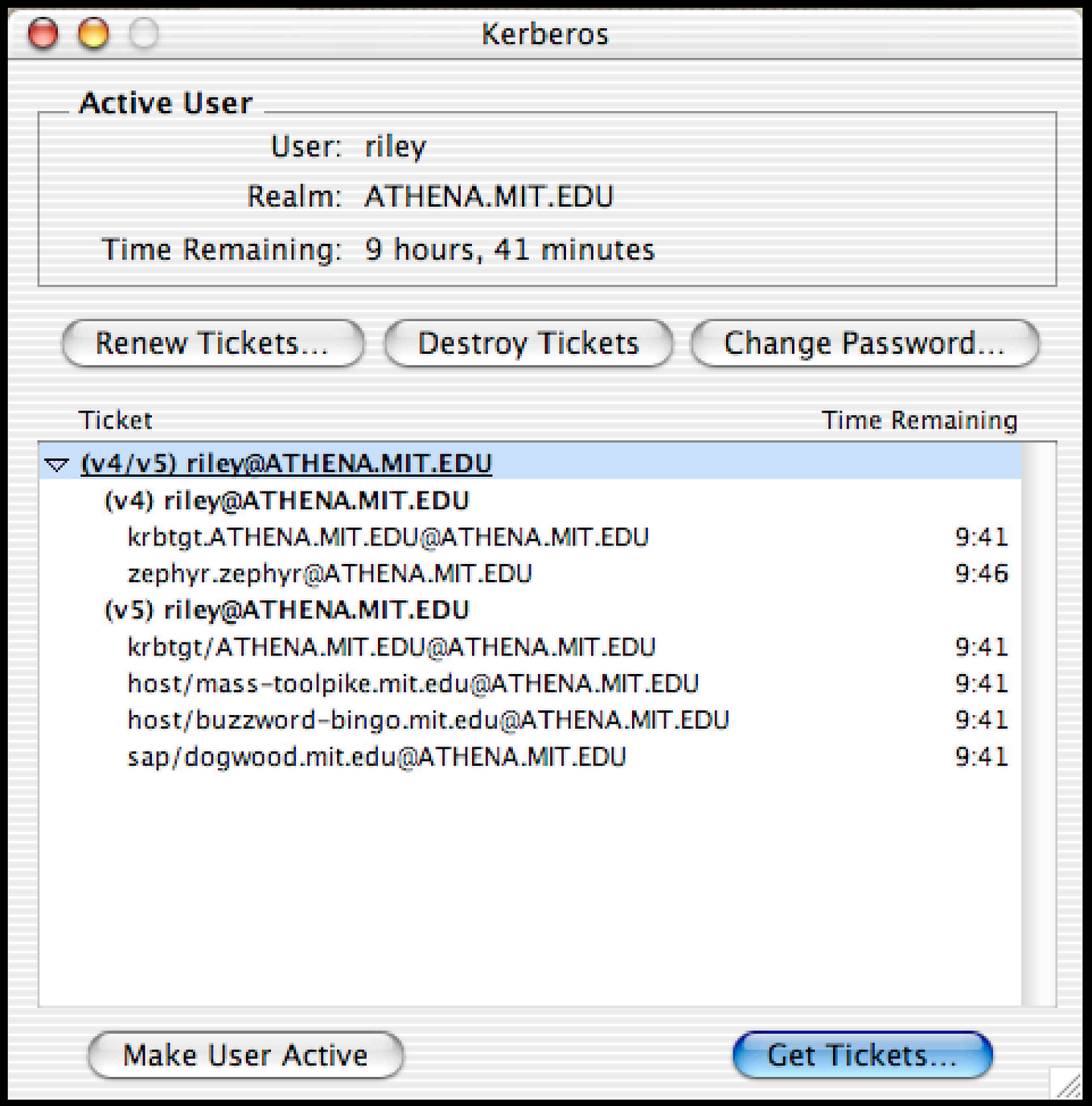
- Server sends back whether the client was authorized and whether encryption was selected

Connecting to a Service

- Base protocol proceeds as normal with encryption
- Can use session key to negotiate encryption keys
- All ticket exchanges are invisible to the user
- Connecting to a service is automatic
  - No need to type password in again
  - Negotiation of Kerberos features automatic
- Allows for single sign-on



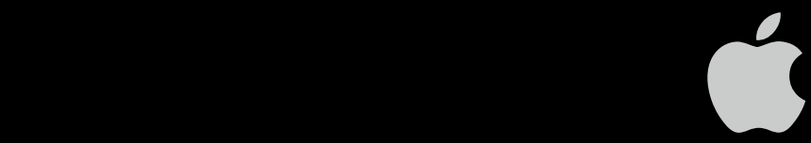
Connecting to a Service



Kerberos Infrastructure

Kerberos Infrastructure

- Three styles of KDC setups
  - MIT KDC
  - MIT KDC with Microsoft Active Directory
  - Apple KDC
- General KDC recommendations



MIT KDC

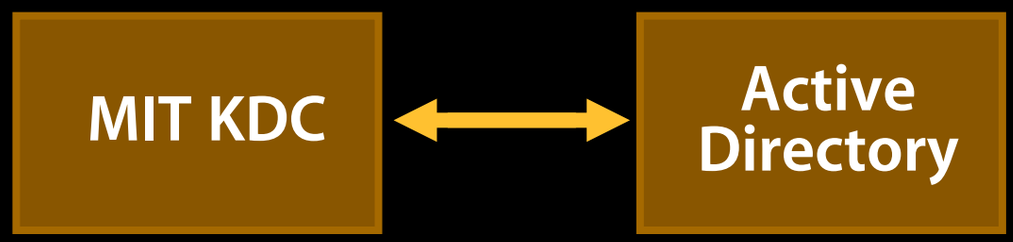
- Provides best support for cross-platform environments
- Provides flexibility for special deployments such as AFS
- Complex to manage and configure
- Source code available

MIT KDC With Active Directory

- Provides good support for Windows integration
- There is a cross domain trust between AD and MIT KDC
- MIT KDC contains
  - Canonical user accounts
  - Host keys for non-Windows machines and services
- There are mappings of user accounts in MIT KDC to accounts in AD Domain

MIT KDC With Active Directory

Account mapping



Non-Windows Application Service

Windows Application Service

User

Apple KDC

- Easy to set up and configure
- Takes advantage of Open Directory
- Password Server contains Kerberos keys and other passwords for legacy client support
- Machines talk to the directory to get configuration and account information
- Machines talk to the Apple KDC for Kerberos authentication

General KDC Recommendations

- Use Tripple DES or RC4 instead of DES for all keys
- Set the preauth_required flag on user principals
- Run as few other services as possible on your KDC
- Avoid Kerberos v4
- Deploy client configuration files with as few settings explicitly set as possible
- Securely backup your KDC

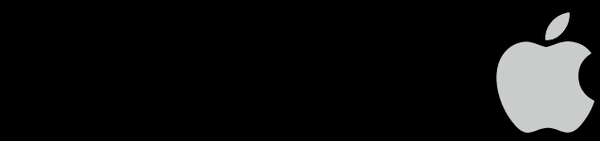
AFS Considerations

- Andrew File System uses Kerberos v4
- Use aklog found at http://mit.edu/openafs to get tokens
- Run a krb524d on your KDC
- Only use Kerberos v4 for the AFS principal; do not globally enable Kerberos v4

Kerberos for Macintosh

Jaguar Kerberos

- Included Kerberos for Macintosh 4.5
  - Kerberos ticket management application bundled
  - Kerberos v5 1.2.6
  - Performance enhancements
  - Improvements to command line utilities
  - 524 support
- Kerberos for Macintosh 4.5.1
  - Released with 10.2.3 software update



Panther Kerberos

Kerberos for Macintosh 5.0

New features include:

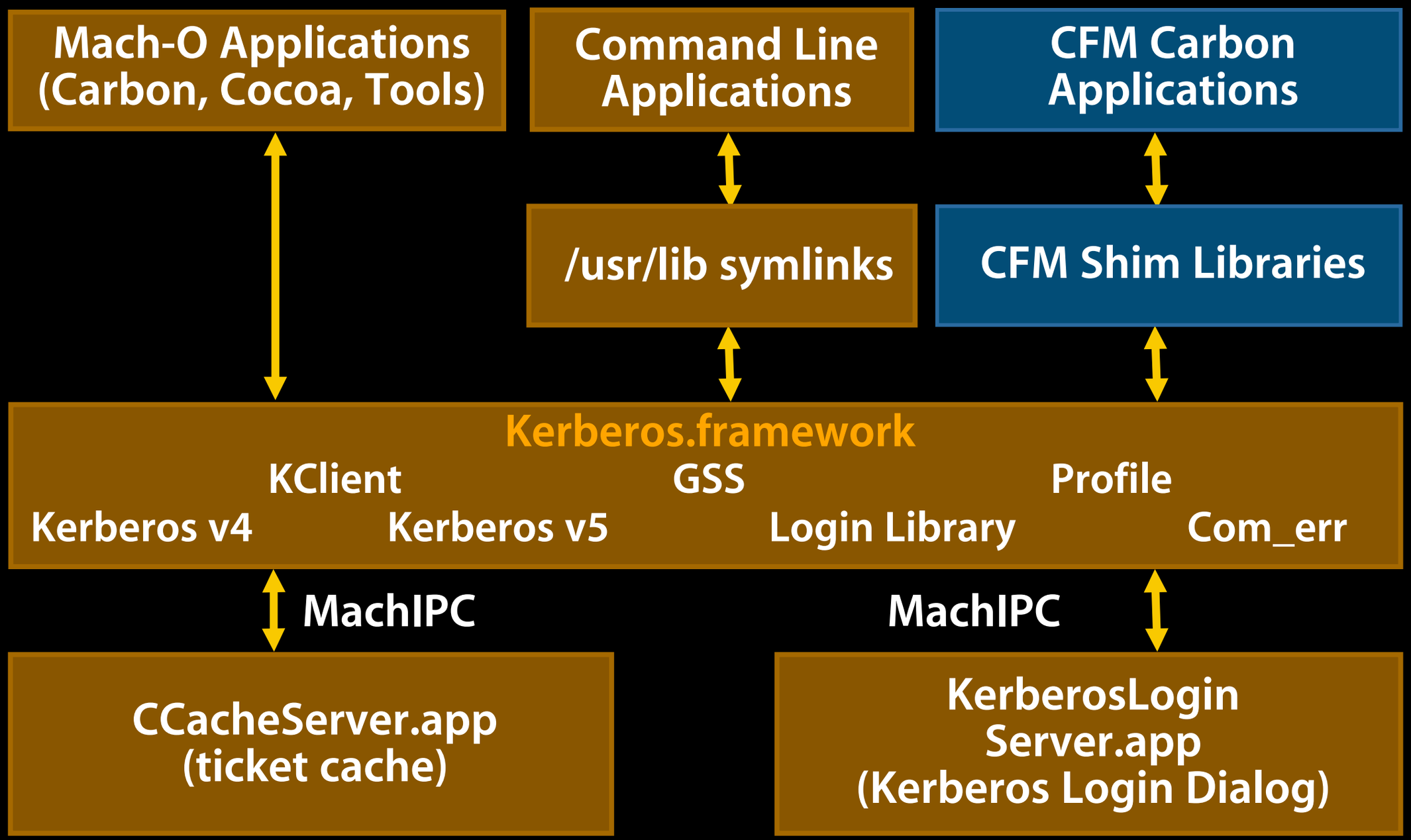
- MIT Kerberos v5 1.3
- Improved Windows interoperability
- New Kerberos Login Dialog
- UI for Addressless tickets (NAT mode)
- DNS support for KDC lookups
- Renewable Ticket Granting Tickets

Panther Kerberos

Kerberos for Macintosh 5.0

- Server components now included
  - Standard MIT KDC and related daemons
  - Common tools to operate a MIT KDC
    - kadmin
    - ktutil
- Apple includes a more integrated KDC as part of Panther Server

KfM 5.0 Architecture



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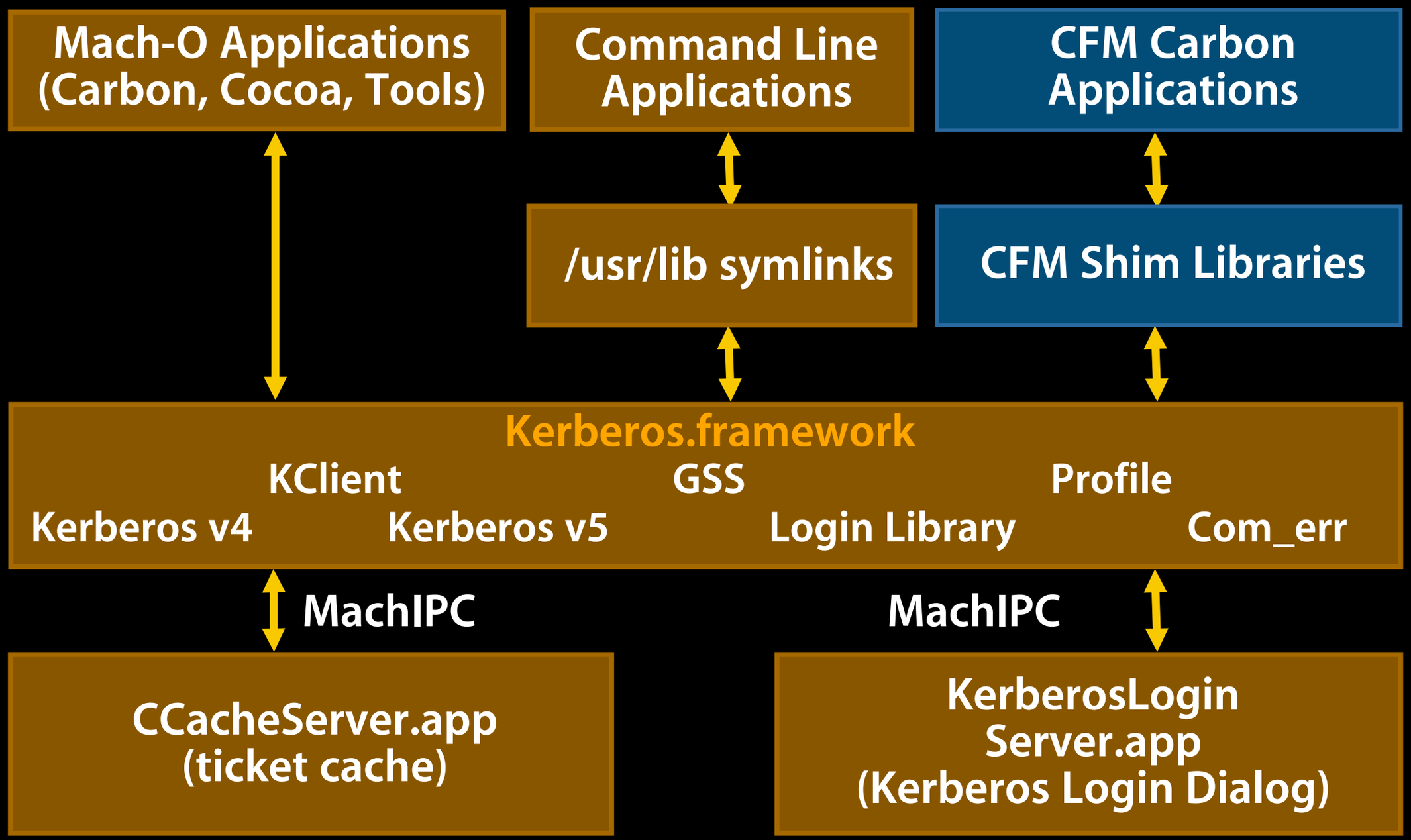

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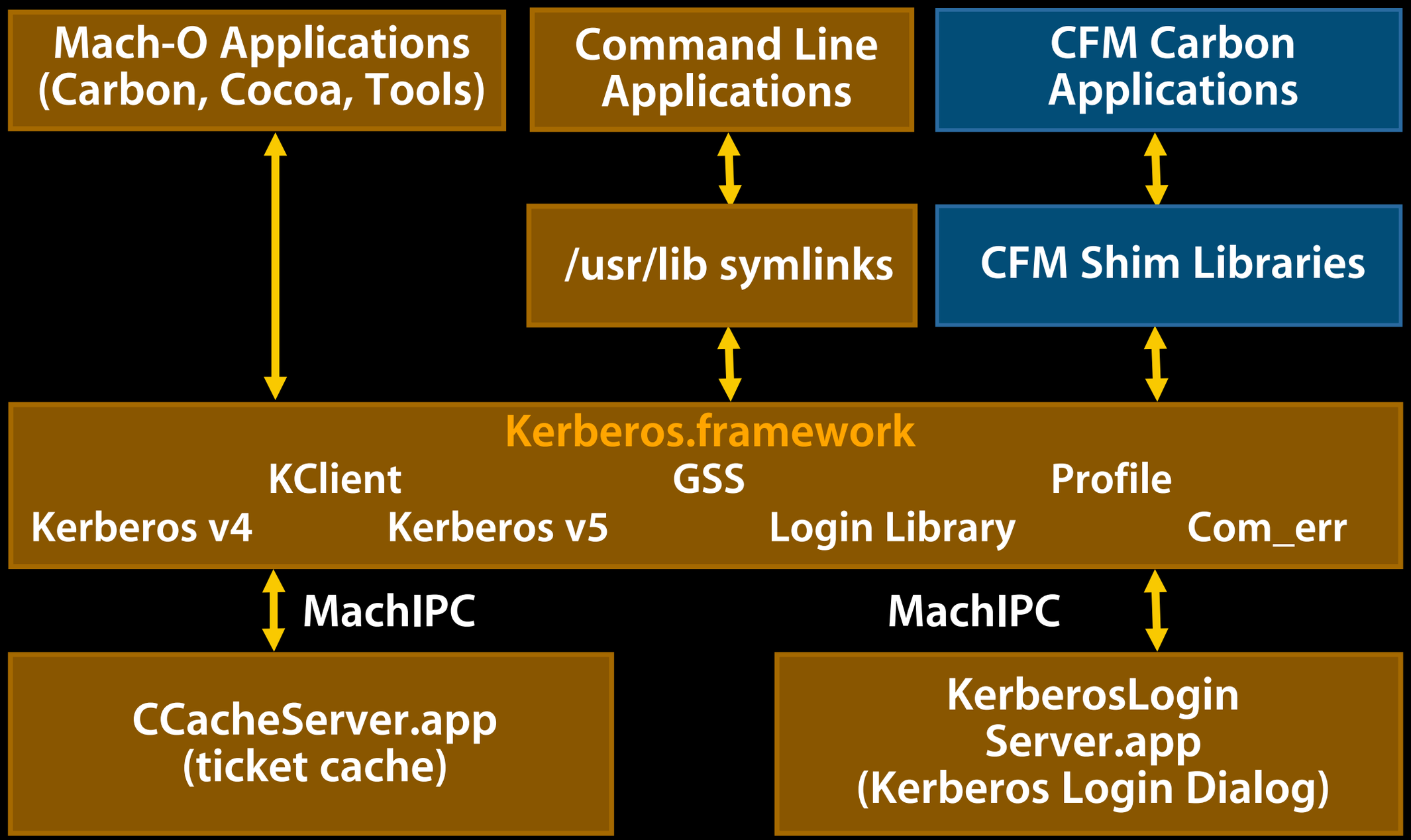

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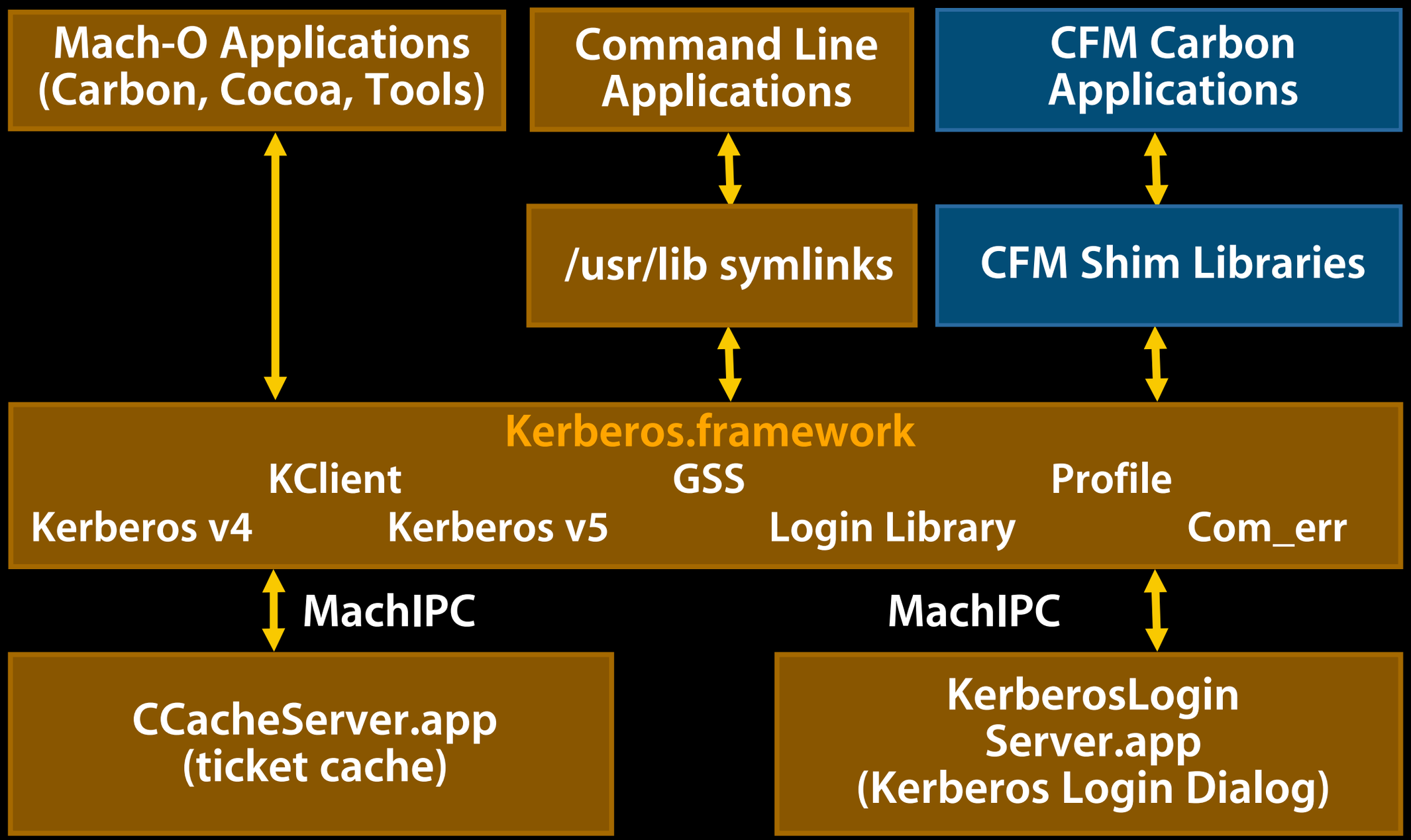

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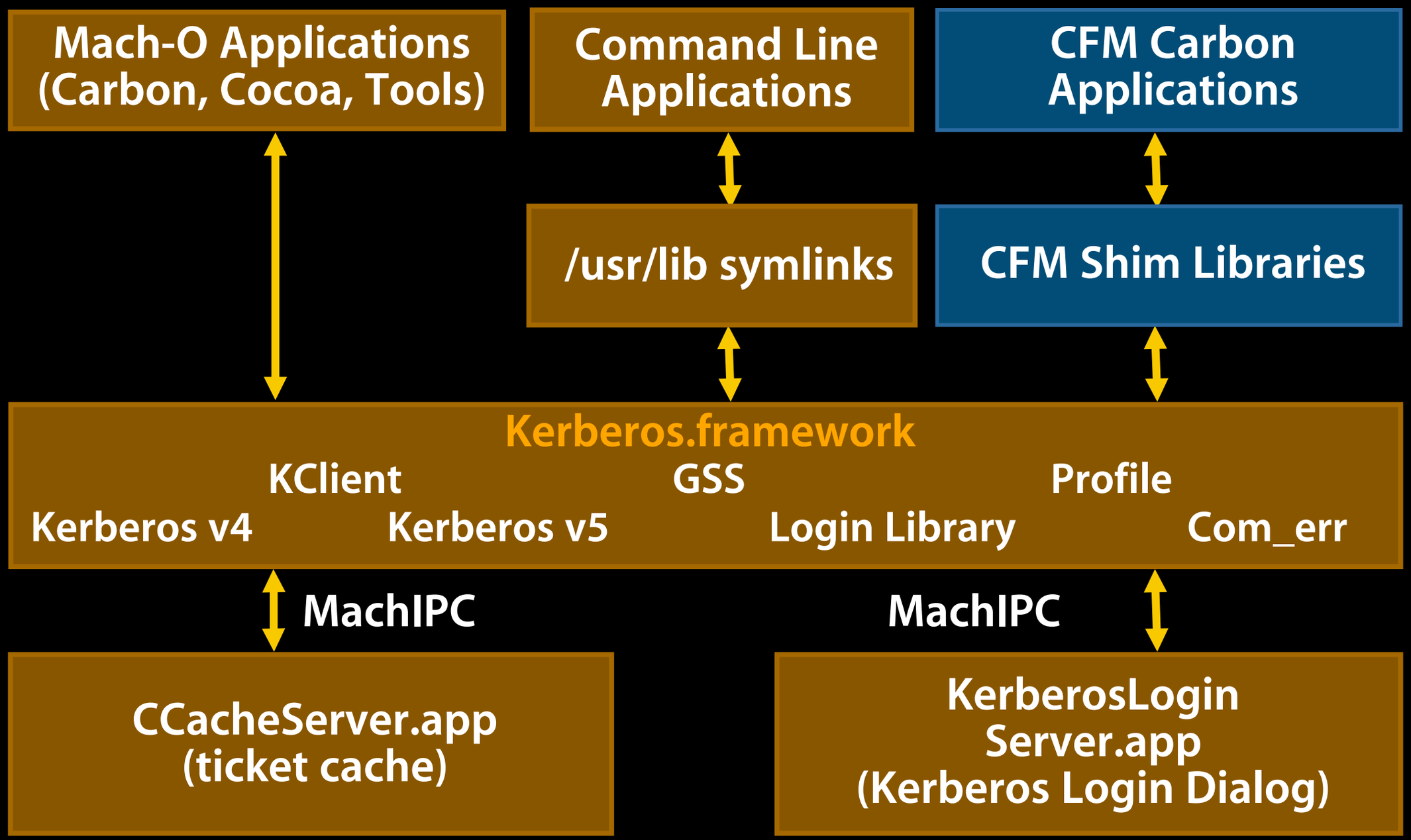

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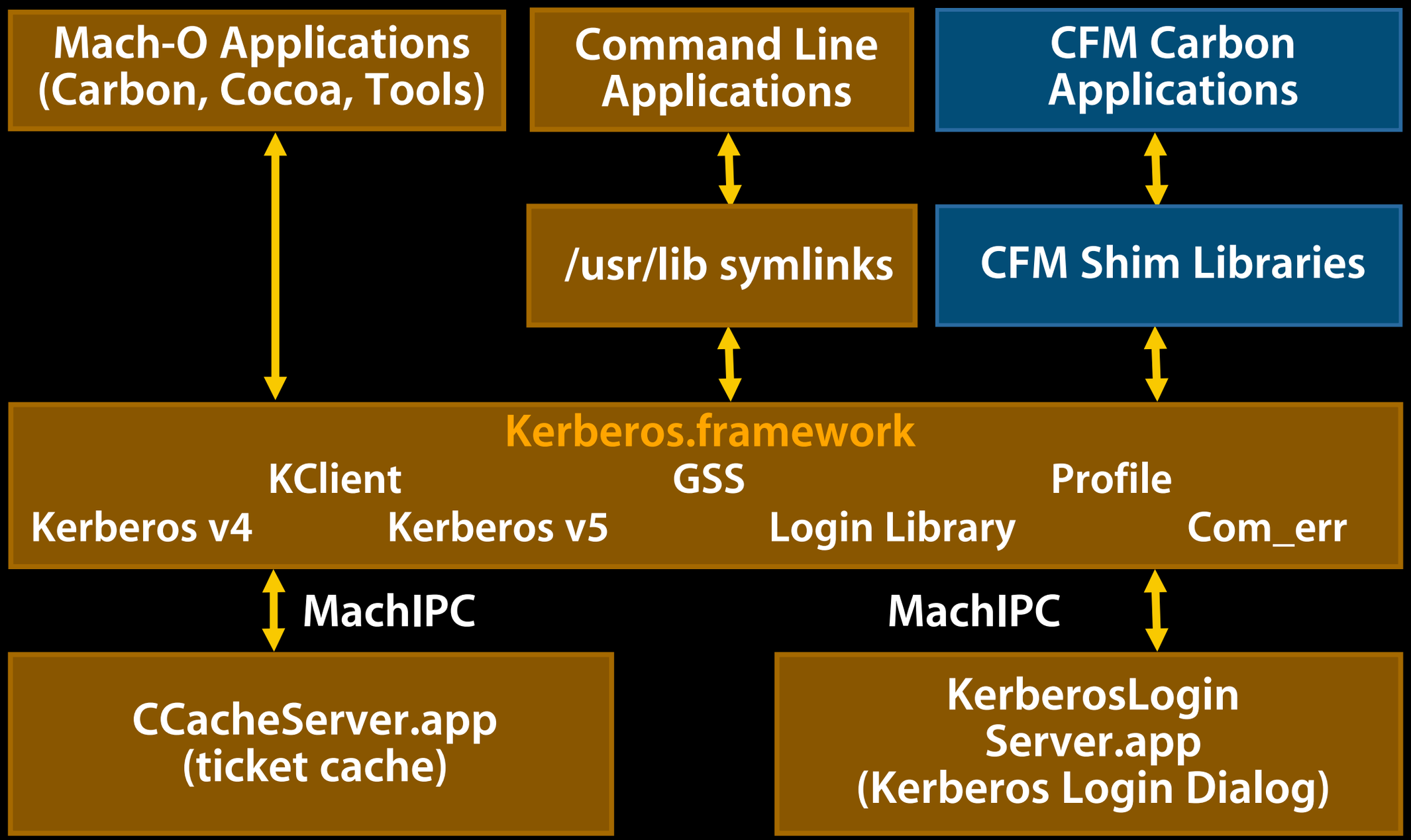

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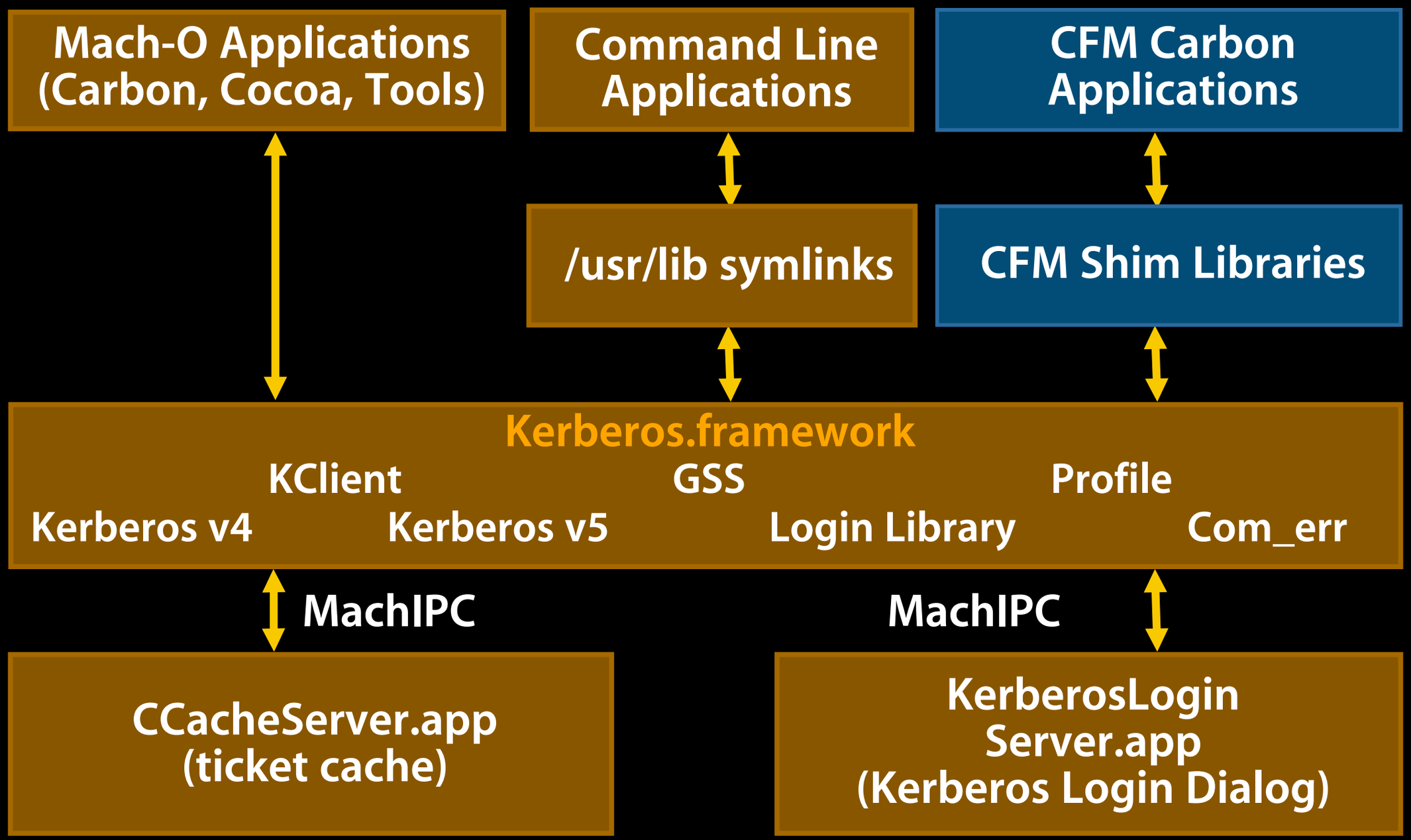


Kerberos v4

- KClient 3.1
  - API compatibility libraries
  - Modern version 3 APIs
- Kerberos v4 implementation
  - Now based on MIT's core v4 compatibility library
  - Modifications to support Kerberos Login Library
- Applications can use either API for v4 calls
  - Should not develop new code for v4

Kerberos v4

Why you should no longer use it

- Only supports DES
- Cannot get addressless tickets
- Tickets do not support various feature flags
- Microsoft offers no native support for v4
- Serious security vulnerabilities
  - CERT VU #623217, 442569
- There is a solution…

Kerberos v5

- MIT Kerberos v5 1.3
  - RFC #1510: “The Kerberos Network Authentication Service”
  - Enhanced support for current IETF draft of “Kerberos Clarficiations”
- GSSAPI
  - Supports:

    RFC #2744: “Generic Security Service API: C-bindings” and
    RFC #1964: “The KerberosVersion 5 GSS-API Mechanism”

MIT Kerberos v5 1.3

- Improved Microsoft Windows interoperability
  - TCP support added to client libraries and KDC
  - RC4 crypto system
  - Microsoft set-password protocol
- Improved support for IPv6
- Initial AES support
- Builds on Darwin systems
- Many bug fixes and feature improvements

Microsoft Interoperability

- Active Directory can be used as a Kerberos v5 KDC to Mac OS X Kerberos clients
- Simple and Protected GSS-API Negotiation Mechanism (SPNEGO) currently has no public counterpart on Mac OS X
- Security Support Provider Interface (SSPI) is very similar to GSSAPI
- TCP communication now supported
- RC4 crypto system now supported

Credentials Cache

- Bottom layer—where the tickets/credentials are stored
- Stored in memory as opposed to on disk
  - More efficient flexibility in handling multiple credentials
- Provides a cross-platform API for accessing the credentials used by v4 and v5 libraries

Kerberos Login Library

- Simplifies the process of getting Kerberos TGTs
  - Allows you to get or destroy tickets with a single call
  - Transparently handles v4 and v5 initial tickets
- Also provides API for adjusting Kerberos Login Dialog options
- Used by programs that need to perform actions on TGTs, such as administrative applications

Other Libraries

- Com_err
  - Access error codes returned by Kerberos
- Profile
  - Read information stored in the Kerberos configuration file (for example, library defaults, realms, etc.)

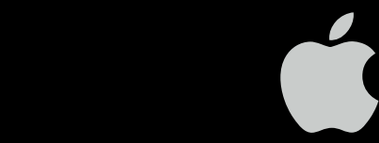
Kerberos Application

- Provides a UI for obtaining, destroying, listing, and displaying information about tickets and currently authenticated users
- Also provides a UI for setting
  - Kerberos Login dialog options
  - Favorite realm
- Dock icon presents ticket status and menu

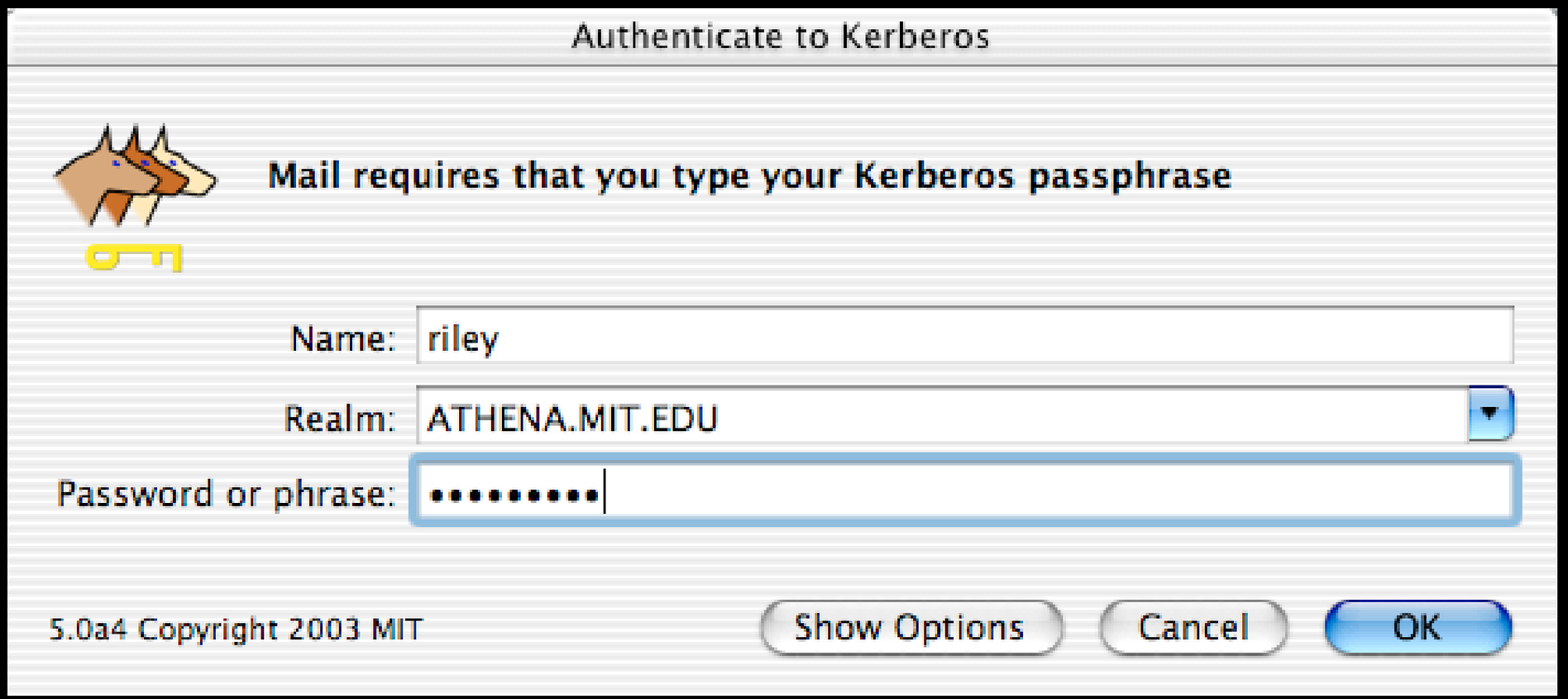
Kerberos Application

New features

- Additions for editing new Kerberos Login Dialog defaults
- Improved performance and appearance
- Enter realms for DNS in Favorite Realms
- New time ranges for setting renewable ticket options
- Auto renews TGTs when applicable



Kerberos Login Dialog



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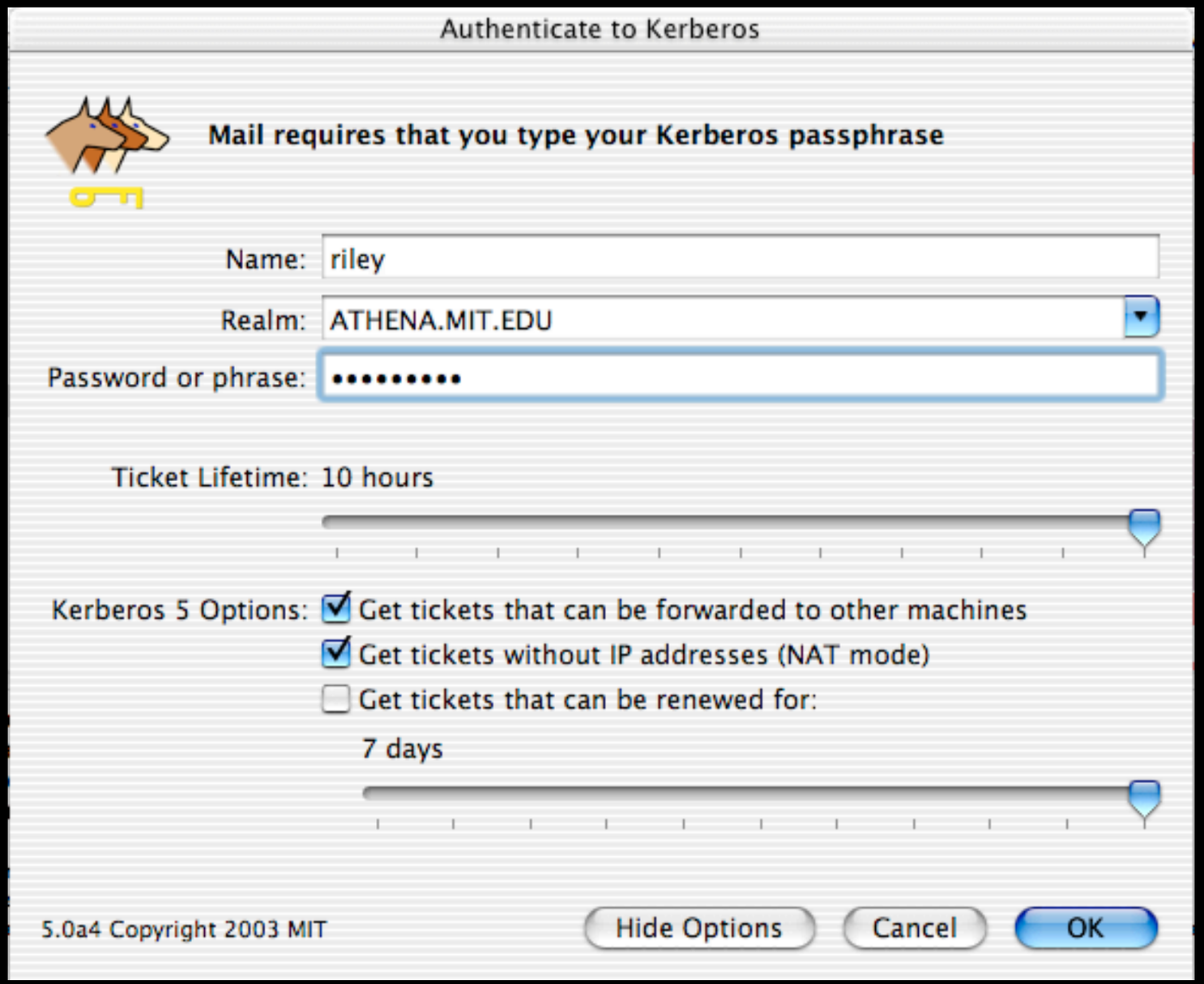

Panther Kerberos Considerations

- Kerberos Login Dialog password field changed from MacRoman to UTF-8
- New CFM bridge libraries required
- Command line clients no longer automatically prompt when no tickets are available
- krb524 authentication requires a v4 configuration
- sudo and su now get a new empty ticket cache

Developing for Kerberos

How to Kerberize an Application

- Find the protocol specification (RFCs, etc.)
- Determine which API to use
  (KClient, Kerberos v5, GSSAPI, etc.)
- Figure out how to connect the API to the protocol
  - The data returned by the API usually needs to be massaged into a form required by the protocol (for example, Base 64)

Kerberizing FTP

- Protocol: RFC 2228, RFC 959
- Supports Kerberos v4 and GSS
  - Use KClient API for Kerberos v4
    (better support for multiple sessions)
  - Use GSSAPI for Kerberos v5

Kerberizing FTP: GSSAPI

- Session management and authentication
  - `gss_init_sec_context`
- Encryption and decryption
  - `gss_wrap`
  - `gss_unwrap`
- Connecting the API to the protocol
  - Base 64 encoding

GSSAPI Programming

Basics

- GSSAPI exchanges messages called tokens
- At the beginning of a program, GSSAPI exchanges context tokens to perform authentication and to set up encryption
- Later the program calls `gss_wrap` and `gss_unwrap` to encrypt and decrypt application data
- In general, all application data should be encrypted

GSSAPI Programming

Application choices

- Applications must select what GSSAPI security services they want
- Most applications want to explicitly turn on integrity protection, confidentiality, replay detection, and sequencing
- GSSAPI also provides a facility to forward credentials from one system to another

GSSAPI Programming

Program flow

- GSSAPI potentially requires multiple round trips for authentication
- The application does not know how many round trips are needed ahead of time
- So the application loops waiting for the authentication to finish

GSSAPI Programming

Client loop

```
input_token = NULL;
do {
  major_status = gss_init_sec_context(input_token,
output_token);
  if (output_token)
    send_token( output_token);
  if (major_status == GSS_S_CONTINUE_NEEDED)
    recv_token( input_token);
} while (major_status == GSS_S_CONTINUE_NEEDED);
```

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GSSAPI Programming

Server loop

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      output_token);
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Kerberizing Suggestions

- Use SASL if adding Kerberos to your own protocol
- Using SASL includes using GSSAPI for Kerberos v5 functionality
- GSSAPI helps isolate applications from differences in Kerberos v5 APIs
- Do not add additional Kerberos v4 support

Summary

Points to Remember

- Kerberos is a simple yet power solution to authentication and single sign on
- Provides an unobtrusive authentication experience to the user
- Available on a wide variety of platforms
- Sites should be migrating from Kerberos v4
- Panther and Panther Server will provide a wealth of Kerberized services

Reporting Bugs

- File bugs about Kerberos in Mac OS X with Apple

Wrap Up

Roadmap

101 Security: Architectural Overview The Security Infrastructure in Mac OS X	**The Marina** **Mon., 5:00pm**
607 Authentication in Mac OS X Server Authentication in Mac OS X and Mac OS X Server	**Nob Hill** **Tue., 5:00pm**
610 Directory Services Open Directory for Mac OS X and Mac OS X Server	**The Mission** **Wed., 10:30am**
FF016 Security Feedback Forum Tell Us What You Think	**North Beach** **Fri., 2:00pm**

Who to Contact

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Massachusetts Institute of Technology
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Skip Levens
Server Technology Evangelist
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http://developer.apple.com/wwdc2003/urls.html

For More Information

Reference Library

Documentation

MIT Kerberos

http://mit.edu/kerberos/www/papers.html

MIT Kerberos for Macintosh

http://mit.edu/macdev/www/kerberos.html

Reference Library

Online Resources

KB107153: Mac OS X 10.2 About Using Kerberos

http://docs.info.apple.com/article.html?artnum=107153

Windows 2000 Kerberos Interoperability and Authentication

http://www.microsoft.com/windows2000/techinfo/howitworks/security/kerbint.asp

Answers to Frequently Asked Kerberos Questions

http://support.microsoft.com/default.aspx?sd=msdn&scid=kb;en-us;266080

Reference Library

Online Resources (continued)

Describing GSSAPI in terms of SSPI

http://msdn.microsoft.com/library/en-us/dnsecure/html/sspikerberos.asp

IMAP4 Authentication Mechanisms

http://www.faqs.org/rfcs/rfc1731.html

Internet RFCs

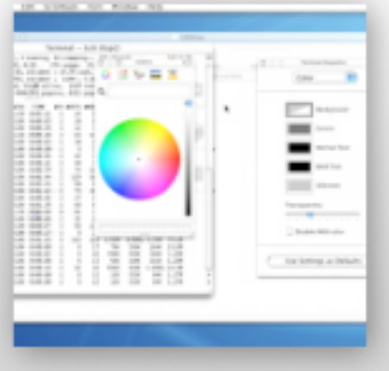
http://www.ietf.org/rfc.html

Source Code

Darwin Kerberos Page

http://developer.apple.com/darwin/projects/kerberos/

Q&A



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http://developer.apple.com/wwdc2003/urls.html

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